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Review

Potential use of barks of woody vascular plants in bone mending: A review

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ABSTRACT

The use of synthetic drugs to overcome bone ailments causes severe side effects, but the application of herbals is helpful in maintaining bone health and accelerating bone mending. Currently, there is no oral allopathic medicine to hasten bone healing, though folk and traditional practices have adopted herbal to fasten the recovery from bone ailments. Earliest recovery is a universally desired phenomenon, especially for elderly people where many more cases of traumatic injuries are common along the compromised body immunity. The computerized database search engines, such as Google Scholar, PubMed, ScienceDirect, Springer Link, etc., and textbooks were used to collect all relevant information about barks for bone mending activity published from 1990 onwards using certain keywords such as bark, folklore/traditional bone healing practices, and phytopharmacology. The results obtained were compiled to make this review and related information is tabulated herewith. Traditional herbal bone healing exists in every society in the world. The plant barks of a few species (e.g., *Ficus religiosa*, *Prunus cerasoides*, *Terminalia arjuna*, etc.) have outstanding significance for bone healing because of their special chemical composition and novel properties to reduce swelling, pain, soreness, and speedy recovery of functions. Mostly bark extracts are rich in polyphenols, and minerals, represented with antioxidant, immunostimulatory, antibacterial properties, etc. There is a diversity of bark utilization for bone healing from different plant species, globally, of which only a few have been phytopharmacologically deciphered. Validated bark ingredients as medicine or food supplements are more useful due to the least side effects. Entrepreneurs have a scope to use bioactive obtained from plant barks that have not been scientifically screened till now. The research focused on the commercial application of plant barks as green medicine needs fingerprints of bioactive and clinically validated data including the concentration of biomarkers in the blood (IC_{50}) for reducing the healing period. Phytopharmacological screening of barks used in folk medicine and synthesizing the therapeutics at mega quantities in industries is an array of hopes for sustainable utilization of natural resources. The bio-stimulating knowledge of certain herbal ingredients will be helpful in the development of synergistic formulations for rapid bone mending.

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Contents

1. Introduction

Herbs have helped bone healing for thousands of years (Kirtikar and Basu, 1993; Banu et al., 2012) while modern practices are a phenomenon a century-old only. Bone, as an organ, can heal naturally, via a proliferative and physiological process facilitated by the body itself for an ailment (Dimitriou et al., 2011). Bone mending is a process of tissue and cell proliferation and differentiation. Many factors, including inflammatory cytokines, growth, antioxidants, osteoblast and osteoclast cells, hormones, uncounted nutrients, and amino acids are involved in the bone-mending process. In general, bone cleavage remedy consists of pushing to relocate the bone to its place with or without anesthesia to stabilize the position, and waiting for natural healing (Singh, 2017). There are a few novel approaches to treating bone defects as using scaffolds, bioactive molecules, and stem cells. Generally, modern medical practices cure bone fractures using plaster or cast to immobilize the cleavage bone, followed by anti-inflammatory and analgesics drugs (Dimitriou et al., 2011), and currently, there is no oral medicine available for hastening bone repair (Ngueguim et al., 2012), but a few herbals used in folk medicine to strengthening the broken bone, weak bone, brittle bone, low-density bone, etc. are believed to have constituents that work synergistically for a fast bone healing (Singh et al., 2020).

Herbs are described for hasting bone healing without any adverse effects in the Sushruta (500 BCE), and Hippocrates (400–335 BCE) (Singh, 2017). There is in writing the use of manipulation, traction, immobilization by a special variety of clay, and by a splint, and use of the impregnated bandage with resin to immobilize the injured limbs in the Sushruta and Hippocrates, as currently Plaster of Paris is used to bring and maintain the ends of cleavage bone together to connect the gap that continues unhampered (Singh, 2017).

Though bone healing is followed by biological principles, mechanical measures are to be harmonized along with protein nutrition, an essential ingredient for the mending of long bone cleavages (Guarniero et al., 1992). A routine diet may have sufficient protein for bone healing to a small and a medium–sized cleavage gap but to a large–sized fractured gap, requires a specific protein supply along the adequate mechanical support (Chen et al., 2009).

Literature surveys have revealed that a few molecules extracted from plants have high regenerative, anti-inflammatory, and antioxidant effects, a requirement for successful bone healing (Arulselvan et al., 2016), though the mechanisms of the inflammation and consequently the bone healing processes are still poorly deciphered. Current knowledge on the impact of barks on bone mending is fragmented, and it is assumed that the action of the folk medicines obtained from the bark is related to a decreased tissue inflammation, an increase in the antioxidant defenses, an increase in the proliferative activity of the bone cells, and vascularization of the tissue (Miranda et al., 2019). The anti–inflammatory ingredients of pant barks control the swelling and relieve the pain and finally, promote overall healing during inflammation (Singh, 2017).

Plant barks of both roots, and stems have different biomolecules such as alkaloids, glycosides, polyphenols, steroids, vitamins, terpenes, etc. that tend to serve as potential therapeutic agents to cure bone ailments (Singh et al., 2020) There are several plants barks described and used in different traditional therapy to heal the bone, which act as a safe, economic, and effective alternate treatment (Singh, 2017, Singh et al., 2020). The adoption of herbals as an alternative medicine to accelerate the bone mending process, reduce the healing period and treatment cost, and quickly regain good health is still a matter of detailed phytopharmacological investigation along the half maximal inhibitory concentration (IC_{50}) of each ingredient in the human blood. The objective of the present article is to narrate a detailed exploration of various barks of woody vascular plants to explore a direction for further research to develop a modern green medicine or food supplement for rapid recovery from bone ailments, especially to overcome the elderly stage associated with compromised body immune system.

2. Materials and methods

An extensive literature survey was made by using electronic database searches engines, such as Google Scholar, PubMed, ScienceDirect, Springer Link, and Web of Science to gather all relevant information as research articles published from 1990 to February 2023, using keywords such as ‘plants bark’, ‘folklore’, ‘traditional’, ‘bone healing practices’, and ‘phytopharmacology’. The preferred reporting items for systematic reviews and *meta*-analyses (PRISMA) strategy was adopted to select all studies cited in this

Table 1
Phyto-pharmacological information on plant bark traditionally used for bone-mending.

S. No.	Description of plant	Traditional uses	Phyto-pharmacology	
			Active ingredients	Pharmacological properties
1.	*Alangium salvifolium*(L. f.) Wangerin (fam.: Alangiaceae)	The paste of root bark is applied to the affected area and bandaged. Powdered roots either as such or its decoctions are used to treat arthritis (Uphof, 1968).	Ankorine, deoxytubulosine, ipecac, lacinilene C7-methyl ether, tubulosine, etc. (Siddaiah et al., 2020).	Methanolic extract of roots barks has analgesic and anti-inflammatory properties in Wistar albino rats. The ethanolic extract of roots bark is comparable to diclofenac sodium (Tanwer and Vijayvergia, 2014).
2.	*Debregeasia salicifora*(D. Don) Rendle (fam.: Urticaceae)	Bark-paste is applied locally to treat fractured bones (Dangwal et al., 2010; Pande et al., 2007)	Oleanoic and ursolic acids, phytosterols, flavonoids, tannins, and anthraquinone (Akbar and Malik, 2002; Wolska et al., 2010).	Antibacterial, anti-fungal, and anticancer activities have been reported based on in-vitro cellular models (Almubayedha and, Ahmad, 2019).
3.	*Diospyros Chloroxylon*Roxb. (fam.: Ebenaceae)	Stem bark paste is used externally, and orally given once a day in the early morning for bone healing (Sirisha et al., 2018).	Anthraquinones, tannins, saponins phytosterols, and terpenoids (Naik et al., 2021).	Research results based on bacterial cells have revealed that bark helps in wound healing, and tannins bind to proline–rich proteins and interfere with protein synthesis (Thomas et al., 2013; Sirisha et al., 2018).
4.	*Erythrina variegata* Linn. (fam.: Fabaceae, sub-fam.: Papilionoideae)	The bark is used to treat rheumatic joint pain, spasms of the limbs as well as lower back and knee pain (Kawashima et al., 2004).Barks with leaves are used to relieve joint pain (Gurung, 2002)	Isoflavones that have chemical structures like the mammalian estrogens (Hidaka et al., 2003; Mathey et al., 2004).	i. Bark extract suppresses bone resorption and the high rate of bone turnover induced by estrogen deficiency in rats (Zhang et al., 2007).ii. Studies on rats have revealed the protective effect of bark to mediate the suppression of osteoclast differentiation and maturation (Zhang et al., 2010).
5.	*Eucommia ulmoides* Oliv. (fam.: Eucommiaceae)	The stem bark is used for a sturdy, skeletal structure, and strong-flexible joints (Hussain et al.,2016)	Iridoids, isoflavonoids, lignans, phenolics, and terpenoids (Hussain et al., 2016).	The bark contains *iso*-flavonoids, which have estrogen-like properties and binds to human estrogen receptors (Ong and Tan, 2007).
6.	*Ficus religiosa* Linn. (fam.: Moraceae)	The stem bark is used to treat bone fractures (Kirtikar and Basu, 1993). Two spoonsful of stem bark paste are administered twice daily for 21 days. The paste is also applied to the affected part and bandaged (Suneetha et al., 2011)	Alkaloids, phenols, tannins, steroids, flavonoids, β-sitosterol D-glucoside, vitamin K, n-octacosanol, methyl oleanolate, lanosterol, stigmasterol, lupen-3-one, etc. (Anandjiwala et al., 2008)	1. Stem bark extract has a promising immunostimulant effect on albino mice (Mallurwar and Pathak, 2008).2. Aqueous bark extract reduces oxidative stress (You and Nicklas, 2006) with significant antidiabetic activity in streptozotocin-induced diabetic rats (Pandit et al., 2010), hence, useful in bone healing of a diabetic person.
7.	*Grewia optiva*J. R. Drumm. ex Burret (fam.: Malvaceae)	The inner bark (fiber)-paste is applied as plaster for bone healing (Gaur et al., 1993).	*β*-sitosterol, lupeol, stigmasterol, grewialin, and optivanin (Uddin et al., 2013)	Fibers are rich in antioxidants (DPPH and ABTS assays), and used to treat oxidative stress, and neurological disorders (Zahoor et al., 2020).
8.	*Litsea glutinosa* (Lour.) C. B. Rob (fam.: Lauraceae)	Stem bark aqueous paste is used as a plaster in cases of sprain, bruises, back pain, inflammation, rheumatic and gouty joints, bone fractures, etc. (Parikh and Rangrez, 2012)	Bark has steroids, tannins, triterpenoids, and saponins. Aporphine, an alkaloid, is 1.12% (w/w) in the stem bark (Mandal et al, 2000).	Bark has analgesic, antiseptic, and emollient effects in rats (Devi and Meera, 2010). The antioxidant character of bark is due to the aporphine (Sukh Dev, 2006).
9.	*Pinus wallichiana* A. B. Jacks. (fam.: Pinaceae)	Stem bark paste is applied as plaster over the bone fracture (Gaur et al, 1993).	Catechin, quercetin, kaempferol, rhamnetin, isorhamnetin, myricetin., gallo-catechin derivatives, sugar, and derivatives (Naeem et al., 2010)	Terpenoids and flavonoids act as strong antioxidants and potent free radical scavengers. These compounds modulate the oxidative balance of the living system and inhibit microbial activities (Naeem et al., 2010).
10.	*Prunus cerasoides* D. Don (fam.: Rosaceae)	Decoction of stem bark is concentrated at low temperatures and applied to cure joint pains (Chopra et al., 1986).	The stem bark has prunetin, sakuranetin, genistein, and genkwanin, etc (Jangwan and Bahuguna, 1989). It is a source of tannins (CSIR, 2000).	The aqueous extract of stem bark is a potent antimicrobial and is under investigation as a future source of drugs for microbial resistance (Arora and Mahajan, 2018).
11.	*Syzygium cuminii* (Linn.) Skeels (fam.: Myrtaceae)	The stem bark is used for bone healing (Sudarsanam et al, 1995).	The bark of *S. cumini* is rich in tannin (Muruganandan et al, 2001).	Aqueous ethanolic extract of *S. cumini* bark has a potent anti-inflammatory without any side effect on gastric mucosa in mice (Muruganandan et al, 2001).
12.	*Taxus wallichiana* Zucc. (fam.: Taxaceae)	Bark-paste is applied locally to treat fractures and headaches. Bark and leaves are used in a steam bath to treat rheumatism (Juyal et al, 2014).	Taxol and related bioactive toxoids, phenols, steroids, alkaloids, polyphenols, tannins, saponins, diterpenes, anthraquinones, etc. (Bala et al.,1999).	Studies on rats have revealed that stem bark has analgesic, anti–inflammatory, and anti-microbial properties (Qayum et al., 2012).
13.	*Terminalia arjuna* (Roxb.) Wight & Arn (fam.: Combretaceae)	Powder of stem bark is used orally to treat bone fractures (Singh, 1995).	The stem bark contains $CaCO_3$, tannin, saponins, flavonoids, gallic acid, ellagic acid, oligomeric pro-anthocyanidins, phytosterols, and minerals (Giri et al., 2012).	The stem bark has hemostatic properties. Ethanolic extract of *T. arjuna* has a beneficial effect on fracture healing in rats. It is due to the presence of tannins, saponins, and terpenoids. Calcium, phosphorus, and alkaline phosphatase plays important role in osteoblastic activity (Giri et al., 2012).
14.	*Ulmus wallichiana*Planch. (Fam.: Ulmaceae)	The stem bark is used to treat fractured bones (Gaur et al, 1993; Arya et al., 2008).	Different flavonoid-C-glycosides are present in stem bark (Rawat et al., 2009).	Studies on rats have revealed that flavonoid-C-glycosides have the property to stimulate osteoblast differentiation, a bone anabolic function that is desirable for osteoporosis therapy (Maurya et al., 2009; Sharan et al., 2010)

article (Moher et al., 2009). Books such as 'Herbalism, Phytochemistry, and Ethnopharmacology', 'The medicinal plants of the Sikkim Himalaya', 'Indian Medicinal Plants', 'Glossary of Indian Medicinal Plants', 'The Useful Plants of India', and 'Folklore Herbs of Manipur Phytopharmacology' were used while searching for relevant information about the plant with no time limit.

The secondary search was conducted by screening the selected references in the first search. All descriptors were combined in a complete four-level search strategy based on (i) stem bark, (ii) root barks, (iii) folklore/-traditional bone healing practices, and (iv) phytopharmacology. Further, terms like bark, phenolic compounds, polyphenols, minerals, woody vascular plant, rhytidome, biological activity, antioxidant, antibacterial, anti-inflammatory, immunostimulatory, antimutagenic, and antitumoral keywords, were used. Publications lacking sufficient evidence and proof were excluded, and 54 publications with high citations were retained.

3. Results and discussion

The literature survey provided a list of 14 plant species of different families of which barks have been phyto-pharmacologically studied up to an extent (Table 1). These plants' barks are mostly from different geo-climatic regions and are either from roots or stems. Of these species, while *Erythrina variegata* Linn. is of Chinese origin and has vast application in TCM (traditional Chinese medicine), the rest 13 species are from the Indian sub-continent and are practiced in Ayurveda for centuries. The application of these barks has been described either as an extract, paste, poultice, or administered orally, even as a splint without a cast. There are also a few plant barks used in folklore but have not been phytopharmacologically screened by the time.

Plants barks used for bone healing have been found rich either in glycosides, minerals, tannins, terpenoids, flavonoids, or phenols or in a combination of these classes, which revealed the biological role of these ingredients to enhance the rate of bone healing. Additionally, it was found that the selected plant bark used in bone healing may be from either root or stems. According to the nature of bone ailments, these barks have been used either as an extract, poultice, a food supplement, or together with a splint without a cast to immobilize the fractured bone in traditional practices for fracture bone healing (Table 1).

3.1. Chemistry of barks used for bone mending

The bark is a set of dead tissues of woody vascular plants, and many plant species have therapeutic ingredients in their bark (Fig. 1). In general, the bark contains lignin, minerals, polyphenolic compounds, polysaccharides, and suberin (Feng et al., 2013). As per chemical structure, polyphenolics are divided into sub-groups as phenolic acids (hydroxycinnamic acids, hydroxybenzoic, etc.), flavonoids (flavanones, flavanonols, flavones, flavonols, anthocyanidins, tannins, isoflavones), and lignans (Dopico-García et al., 2008). Polyphenols are essential for the development and growth of plants and their reproduction, and defense against various pathogens (Naczk and Shahidi, 2006; Popa, 2015). The most common phenolic acids in plant barks are derivatives of benzoic acid (gallic, vanillic, protocatechuic, and syringic acid) (Pereira et al., 2009, Bocalandro et al., 2012; Garcia-Perez et al., 2012), and cinnamic acid (caffeic, p-coumaric, synaptic, and ferulic acid) (Maldini et al., 2009; Pawar and Dasgupta, 2018). Though flavonoids are aglycones in plants, most flavonoids are in the form of glycosides and are stable derivatives (Tsao, 2010). The most prevailing sub-groups of flavonoids found in the bark of woody plants are flavonols (kaempferol, quercetin, myricetin, etc.) (Garcia-Perez et al., 2012; Vazquez et al., 2008; Brusotti et al., 2015; Chew et al, 2011; Keshari et al., 2016), flavanonols (taxifolin) (Vazquez et al., 2008, Chew et al., 2011; Comandini et al., 2014), flavones (apigenin, luteolin), flavanols (Kemppainen et al., 2014), catechin, epicatechin (Bocalandro et al., 2012; Vazquez et al., 2008; Chew et al., 2011; Tamashiro et al., 2012), and tannins (Comandini et al., 2014; Kemppainen et al., 2014).

3.1.1. Woody vascular plant bark

In vascular trees, generally, the phloem and outer banks are richer in minerals compared to the wood, though these values significantly differ among the wood species. The mineral content is 1.5 to 10.0% (w/w) on a dry basis (Deineko and Faustova, 2015; Szendrey, 1986; Han and Shin, 2014), and the barks of gymnosperm usually have less ash content compared to angiosperms (Nunes et al. 1999). Al, Ca, Mn, P, Mo, Mg, Cu, Zn, B, Fe, N, Na, Ni, K, Pb, Cr, and Si are present in ash, but N, Ca, and K are usually dominant (Miranda et al. 2012; Wang and Dibdiakova 2014). Plant bark contains an organic content of 3 to 17% (Ugolev, 1986). The other main component of bark is lignin (Feng et al. 2013; Miranda et al. 2012). Lignin and suberin are the two major components of holocellulose (Miranda et al. 2013). Additionally, minerals, are often characteristic of a plant family and species, whereas the quantity of tannin is known for the family or genus (Zhitkov, 1985). These significant chemical differences among the barks of different plant species determine their application. Lignans and their glycosides (Marinos et al., 1992) are known for their chemotherapeutic potential (Saleem et al., 2005).

3.1.2. Minerals and their bone healing potential

Barks rich in calcium, magnesium, potassium, phosphorus, sodium, etc. are important for bone health and accelerate bone healing. Minerals, most especially phosphorus and calcium build up hydroxyapatite; the inorganic ingredient of bones (Singh, 2006). Plant barks with such a mineral combination may be an appropriate dietary source to build up strong bones and helpful in the mineralization of osteoid, during bone formation (Kini and Nandeesh, 2012) Calcium and metabolites of flavonoids contribute to matrix deposition during osteogenesis (Kini and Nandeesh, 2012; Ooi et al., 2012; Xu et al 2006), and promote bone formation (Xu et al 2006; He and Shen, 2014). The water extract of *Peperomia pellucida* (L.) BHK is rich in minerals and is used in the traditional medicine of Cameroon to enhance rapid bone mending. (Kini and Nandeesh, 2012; Florence et al., 2017). Florence et al (2017) have reported that the mineral makeup and composition of *P. pellucida* is an appropriate dietary source for bone healing.

Doetsch et al (2004) have reported that calcium absorption depends on the availability of vitamin D during bone mending.

3.1.3. Stimulatory effect of barks in bone mending

The use of androgen, vitamin D, calcitonin, estrogen, and calcium has been recommended for rapid bone healing. Free radicals have a major role in many degenerative disorders, and Thomas et al., (2004) have reported a correlation between antioxidants and bone mending though, in normal health conditions, there is a balance between antioxidants' defensive systems and free radicals in the body. Oxidative stress, the cause of many bodily ailments, deviates from the body's balance and is a cause of degeneration of the body (Behfar et al., 2008).

Several studies have revealed that hypogonadism is a cause of osteoporotic fractures (Dupree and Dobs, 2004), a major factor of male osteoporosis. The current literature survey reveals that there is no plant bark alone to counter the androgen deficiency except the use of *Eurycoma longifolia* Jack whole root crude powder or capsules of its standardized extract to treat osteoporosis due to androgen deficiency in Malaysia, Indonesian, and Thailand (Effendy et al., 2012).

The application of estrogen enhances fracture healing (Zhang et al., 2007). The barks of *Erythrina variegata* Linn. are rich in iridoids, lignans, flavonoids phenolics, and steroids. It is an important medicinal plant in traditional therapies in India, China, and Southeast Asia, used to relieve joint pain (Gurung, 2002). Its bark is used to maintain bone health by suppressing the high rate of bone turnover due to estrogen deficiency and inhibiting bone loss, along with improving the biomechanical properties of bone (Zhang et al, 2007).

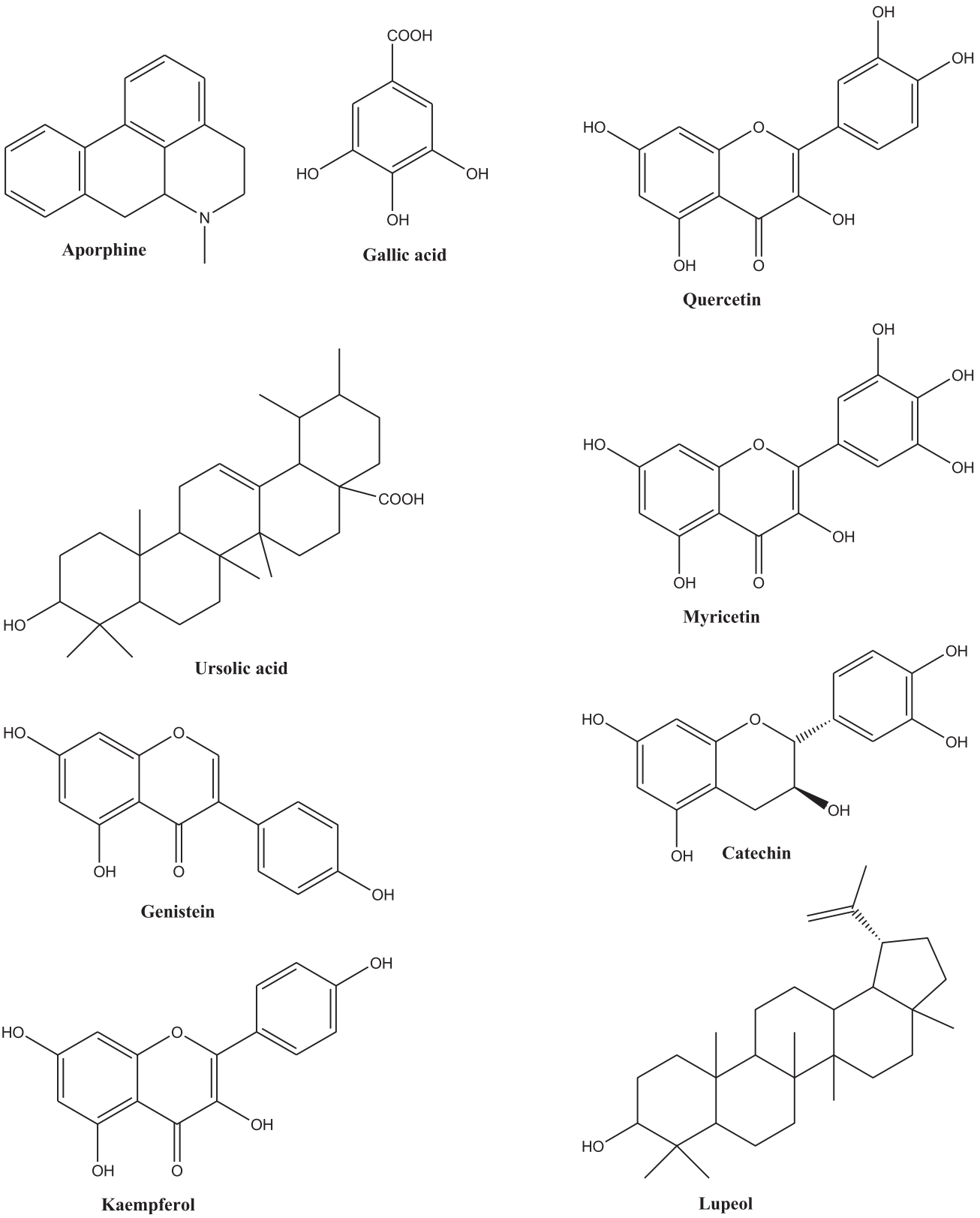
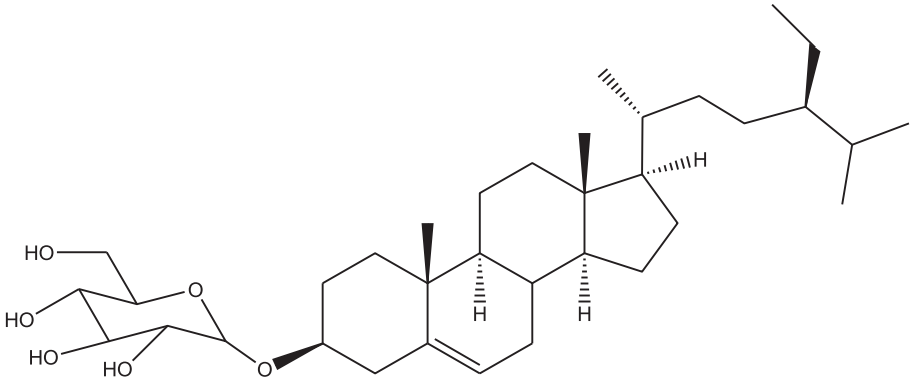


Fig. 1. A few ingredients in plants' barks with potent bone-mending properties.



β-Sitosterol D-glucoside

Fig. 1 (*continued*)

3.1.4. Impact of flavonoids on bone healing

Naringin is a flavonoid that possesses estrogenic activity. It is one of the active ingredients of *Drynariae Rhizoma*, a plant used for bone mending in the TCM (Jeong et al., 2003). Naringin activates estrogen receptor phosphorylation in osteoblasts and inhibits retinoic acid-induced osteoporosis in rats (Wei et al., 2007).

Flavonoids and phytoestrogens having a chemical structure like osteogenic compounds stimulate the recruitment of osteoblasts and increase the activities at the injury site (Doblare et al., 2004; Sharan et al, 2011). Water extracts of *Labisia pumila* (fam.: Myrsinaceae), and *Piper sarmentosum* (fam.: Piperaceae), are traditionally consumed by Malay women. Both herbs are rich in flavonoids and help in maintaining the estrogen level at the postmenopausal stage, and indirectly increase bone formation activity and reduce bone resorption (Manolagas, 2000; Subramaniam et al., 2003). Flavonoids are potent scavengers of free radicals. Free radicals are associated with aging due to oxidative stress and are a major cause of bone ill health (Sies and Stahl, 1995). The antioxidative properties of these herbs protect bone health. There is no attempt to investigate a multiherbal food supplement or herbal medicine enriched in flavonoids for the extent of estrogenic activity in bone healing using barks as one of the ingredients.

3.2. Plants bark in different healing systems

The studies on the folk and traditional use of herbal products for bone healing reveal the potential of phytochemicals to reduce pain and the bone healing period. Hence, herbal medicines are preferred due to their fewer side effects, relatively low cost, and their effectiveness (Venkatesh et al., 2003).

3.2.1. Ayurvedic therapy

The young stem bark of *Ficus religiosa* (Naira et al., 2009) and root barks of *Alangium salvifolium* (Uphof, 1968) are cleaned with the urine of a boy (below 7 years, and below 5 years old), respectively, before grinding. The use of the urine of infants (Jalil et al., 2012) may be for the basification of the plant bark, before processing.

3.2.2. Traditional Chinese medicine

The stem bark of Eucommia ulmoides is a primary herb in Chinese and Korean herbalism for a strong, sturdy skeletal structure, and flexible and strong joints (Ong and Tan, 2007). Its cortex extract is used to induce the release of growth hormones responsible for bone maturation and bone remodeling (Ong and Tan, 2007). Ong and Tan (2007) have reported that sex hormone activities in the body are optimized with the use of E. ulmoides.

3.2.3. Malay traditional medicine

The *Eurycoma longifolia* root aqueous decoction is a popular folk medicine to enhance the free testosterone level in the blood (Ang and Cheang, 2001) and prevent osteoporosis in the Malay region (Katznelson et al., 1996; Aminorroaya et al., 2005; Ali and Saad, 1993).

3.2.4. Egyptian practices

Egyptian physicians had been using the impregnated bandage with resin just as Plaster of Paris is used today to immobilize injured limbs (Singh, 2017). The main objective of this practice is to bring and maintain the ends of cleavages together for natural healing (Singh, 2017).

3.3. Plants barks used in folk for bone mending

Suneetha et al. (2011) have reported the use of root barks [*Dichrostachys cinerea* (L.) Wight & Arn., *Mimosa intsia* L.], and stem barks [*Azadirachta indica* A. Juss., *Cochlospermum religiosum* (L.) Alston, *Eichhornia crassipes* (Mart.) Solms., *Garuga pinnata* Roxb, *Lannea coromandelica* (Houtt.) Merr, *Polyalthia longifolia* (Sonner) Thw., *Terminalia cuneata* Roth., and *Ziziphus mauritiana* Lam.] for healing of the bone fracture (along with a few mentioned in Table 1) used by the indigenous people of Eastern Ghat (India's eastern coastal area). The combined use of root barks and stem barks of *P. longifolia* has been described for bone fracture healing by the same research team.

3.3.1. Mono herbal application

Dutta et al (2019) have reported the use of barks of *Holarrhena antidysenterica* (L.) Wall. ex A. DC., for bone healing as mono herbal application among the Rabha tribe of Assam, India that has been frequently practiced by traditional healers in the region.

3.3.2. Polyherbal formulation

Adhikari et al (2017) have reported the use of barks of *Terminalia chebula* Retz. and *Terminalia bellerica* (Gaertn.) Roxb. in polyherbal formulation (other herbs are *Mimosa rubicaulis, Ziziphus mauritiana, and Berginia ciliate*) for bone fracture healing in ethnomedicines of Western Nepal.

In the present literature survey, no published information was found on the phytopharmacology of barks of these folk plants, though have been described for potent bone-mending properties and deducing the healing period of a fractured bone.

4. Conclusions

Pharmacologically validated folklore bone mending therapies are currently in rising demand. Phytochemical screening of additional botanicals used in folklore for hasting the bone mending, and search for a more potent moiety, will help chemists in synthesizing at a commercial scale and investigate different synthetic analogues as bone menders will lead to an additional source of therapeutics. The bio-stimulating knowledge of certain flavonoids (e.g., androgen, and estrogen) has an array to develop synergistic combinations with other herbs to accelerate the bone-mending process. Clinical investigations along biological pathways to mend bone ailments may link the knowledge gaps between allopathic routes and folk practices. Processing of aqueous extracts at reduced pressure will protect the thermos-susceptible ingredients compared to evaporation as practiced in traditional procedures. Further, the mechanism followed during the release of the medicine in the gastrointestinal tract, and its effective concentration in the blood (IC_{50}), is an essential required data to use the traditional bone-mending plant bark as modern green medicine.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jsps.2023.101714.

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